International Scientific Conference

“Sustainable fruit and berry cultivation”

THE BOOK OF ABSTRACTS

19 November, 2021

Polli, Estonia

Editors: Reelika Rätsep, Hedi Kaldmäe, Karmen Pääso

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Institute of Agricultural and Environmental Sciences

Estonian University of Life Sciences

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CONFERENCE SCHEDULE

INTERNATIONAL SCIENTIFIC ONLINE CONFERENCE "SUSTAINABLE FRUIT AND BERRY CULTIVATION"

Polli Horticultural Research Centre, Institute of Agricultural andd Environmental Sciences, Estonian University of Life Sciences, Polli, Estonia
Date 19.11.2021
Time: 10:00-15:45 (Eastern European Winter Time; GMT +2)

I - FRUIT/ BERRY BREEDING, GENETIC RESOURCES, CULTIVATION TECHNOLOGIES		
	10:00 - 10:10	Opening/ introducing words *Aret Vooremäe, Head of The Polli Horticultural Research Centre, Estonia*
O-1	10:10 - 10:20	*In Memoriam* – Dr. Kalju Kask and his contribution to Estonian fruit breeding *Ave Kikas, Estonian University of Life Sciences, Estonia*
O-2	10:20 - 10:45	**Longer Insight 1** - Fruit and berry breeding, cultivation and research in Estonia *Ulvi Moor, Estonian University of Life Sciences, Estonia*
O-3	10:45 - 11:10	**Longer Insight 2** - Evaluation of Estonian apple cultivars and hybrids in Latvia *Laila Ikase, Institute of Horticulture (LatHort), Latvia*
O-4	11:10 - 11:25	PPP NORDFRUIT – Pre-breeding for future challenges in Nordic fruit and berries *Stein Harald Hjeltnes, Graminor AS, Norway*
	11:25 - 11:40	*Energy break/ poster session*
O-5	11:40 - 11:55	Thirty five years of blackcurrant (*Ribes nigrum* L.) breeding at the National Institute of Horticultural Research in Skierniewice, Poland *Stanislaw Pluta, The National Institute of Horticultural Research (INHORT), Poland*
O-6	11:55 - 12:10	Apple scab control in organic apple orchards *Regīna Rancāne, Lithuanian Research Centre for Agriculture and Forestry, Lithuania*
O-7	12:10 - 12:25	The effect of *Lamiaceae* plants essential oils on fungal plant pathogens *in vitro* *Simona Chrapačienė, Lithuanian Research Centre for Agriculture and Forestry, Lithuania*
O-8	12:25 - 12:40	Precision fertilisation technologies for berry plantation *Indrek Virro, Estonian University of Life Sciences, Estonia*
	12:40 - 13:30	*Lunch break/ poster session*
II - PRE-AND POST-HARVEST FRUIT/ BERRY QUALITY, PROCESSING, VALORISATION		
O-9	13:30 - 13:55	**Longer Insight 3** - Mining profitable nutrients from fruit processing by-products and waste - the Lithuanian perspective *Petras Rimantas Venskutonis, Kaunas University of Technology, Lithuania*
O-10	13:55 - 14:10	Research on fruit and berry by-product valorisation in Estonia *Reelika Rätsep, Estonian University of Life Sciences, Estonia*
O-11	14:10 - 14:25	Cranberry presscake as a source of valuable compounds *Laura Tamkutė, Kaunas University of Technology, Lithuania*
	14:25 - 14:40	*Energy break/ poster session*
O-12	14:40 - 14:55	Biologically active compounds composition of wild bilberries (*Vaccinium myrtillus* L.) – effects of geographic origin, *Dalia Urbonavicienė, Lithuanian Research Centre for Agriculture and Forestry, Lithuania*
O-13	14:55 - 15:10	Influence of apple varieties and microflora diversity on the sensory and volatile profiles of apple cider, *Paul Cristian Călugăr, University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Romania*
O-14	15:10 - 15:25	Novel and hybrid technologies for the valorization of blackcurrant press-cake: from the biorefinery concept towards added-value snack products *Nora Pap, Natural Resources Institute Finland (LUKE), Finland*
	15:25 - 15:45	closing remarks/ ending

LIST OF POSTER PRESENTATIONS

	Title of the presentation and authors
P-1	Collection, identification and characterization of fruit crop genetic resources in Latvia *G. Lācis*, S. Dane, D. Dēķena, I. Drudze, D. Feldmane, I. Grāvīte, L. Ikase*
P-2	Preliminary results of five sweet cherry rootstock evaluation for Estonian cultivar 'Anu' *Dz. Dēķena*, D. Feldmane and V. Laugale*
P-3	Influence of raspberry bushy dwarf virus on pollination of red raspberry (*Rubus idaeus* L.) cultivars *L. Sproģe, S. Strautiņa**
P-4	Influence of vermicompost on strawberry plant growth and dehydrogenase activity in soil *V. Laugale*, S. Dane, S. Strautiņa, I. Kalniņa*
P-5	Effect of rootstock on the growth and early yield of the apple cultivar 'Sinap Orlovski' *M. Järve*, T. Univer*
P-6	Evaluation of the main biological and production traits of Latvian apple cultivars in the conditions of Central Russia *N. Krasova*, L. Ikase, D. Dēķena*
P-7	Suitability of blue honeysuckle (*Lonicera caerula* L.) cultivars for cultivation in the Nordic_Baltic climate M. *Vinogradov*, R. Rätsep, L. Arus*
P-8	Comparison of Polyphenols Content of Different Blackcurrant (*Ribes nigrum* L.) Cultivars at the Polli Horticultural Research Centre in Estonia, *A. Kikas*, R. Rätsep, H. Kaldmäe, A. Aluvee, A.-V. Libek*
P-9	Ascorbic acid, phenolic compounds and antioxidant capacity of traditional Serbian 'Plum cake' *D. Prvulović*, G. Barać, M. Peić Tukuljac, V. Ognjanov, M. Ljubojević*
P-10	Comparison of vitamin C content of blackberry (*Rubus fruticosus* L.) and cornelian cherry (*Cornus mas* L.) from eastern and western Serbia *R. Kolarov*, S. Đorđević, D. Prvulović*
P-11	Green synthesis of silver nanoparticles using aqueous extract of *Viburnum zarnica*- 2 and *Viburnum sargentii* berries antioxidant, antimicrobial activity and phenolic composition, *A. Balčiūnaitienė*, J. Viškelis, P. Viškelis*
P-12	Fruit leaf extracts and their perspectives in the cosmetics industry - preliminary study *D. Segliņa, I. Krasnova, K. Juhņeviča-Radenkova*
P-13	Antioxidant and biological properties of *Quercus rubra* L. fruits *A.E. Tanislav*, R.A. (Vlaic) Marc, M. Niculae, E. Páll, V. Mureşan, A. Mureşan, A. Puşcaş, C.C. Mureşan, C. Cerbu*
P-14	Chemical constituents and antioxidant activity of Aralia cordata (*Aralia cordata* Thunb.) berry, seed, pulp, juice, and pomace *V. Puzerytė*, D. Urbonavičienė, P. Viškelis*
P-15	Characterization of avocado seed powder as an alternative and sustainable ingredient - citotoxicity evaluation and biological activity *A. Puşcaş*, A.E. Tanislav, R.A. Marc Vlaic, V. Mureşan, A.E. Mureşan, M.A. Mateescu, A. Păucean, S. Chis, S. Muste, E. Pall, C.G. Cerbu*
P-16	Antioxidant properties and aroma profile of swallow-wort (*Vincetoxicum lutea* L.) leaves extracts *J. Jovaišaitė*, L. Tamkutė, R. Baranauskienė, A. Pukalskas, P. R. Venskutonis*
P-17	Plant Biology Infrastructure (TAIM) – a platform for plant phenotyping, plant-based innovation and science-intensive developments *Liina Jakobson, Ebe Merilo, Ülo Niinemets, Kalvi Tamm, Cecilia Sarmiento, Hedi Kaldmäe, Kristiina Laanemets, Hannes Kollist*

ABSTRACTS OF PRESENTATIONS

Welcome and introducing words

Dear conference participants and guests,

As director of the Institute of Agricultural and Environmental Sciences of Estonian University of Life Sciences, I have a great honour to greet you at the scientific conference dedicated to the 100th anniversary of Polli Horticultural Research Centre.

Research on fruits and berries in Estonia and at our University is carried out in two locations – at horticultural research centre at Polli village in Southern Estonia and on our university campus in Tartu where the Chair of Horticulture mainly operates. Through the history, Polli village has always been related to horticulture. In 1920, an agricultural school was founded at Polli. 25 years later, a horticultural research centre was established, focusing on breeding fruit varieties. During the last two decades, the focus of the horticultural research centre has shifted from breeding and cultivation technologies towards processing and product development.

The topic of the conference is sustainable fruit and berry production. In the context of EU Green Deal and ambitious goals for tackling climate change, it is very important to readjust our activities in fruit and berry cultivation as well as processing. On the one hand, new pests and diseases that emerge due to global warming call for extra actions for securing plant health and high quality product. On the other hand, EU strategies foresee reduction of pesticide quantities by 50% in the next decade as well as remarkable increase in organic farming. Efforts to reach the goals will lead us to diversification of plant species, varieties and cultivation methodologies. Many currently grown commercial fruit cultivars may prove unsuitable in low-input or sustainable organic farming systems. However, we are sure that our research communities in collaboration with fruit and berry producers will find right directions and solutions for the selection of suitable varieties as well as sustainable pest control methods.

Another important goal is to keep valuable nutrients from waste or residues in the agro-economic cycle. UN Sustainable Development Goals call for reducing food loss in production and supply chain, including post-harvest loss up to 50% by 2030. It will make it urgent to find solutions for producers' side-streams. Valorisation of production side-streams will not only reduce waste but will also help us achieve greater resource productivity. Recent decades have witnessed rapid developments and many good ideas, which will be discussed during the conference.

Today we will have speakers from seven different countries: Estonia, Latvia, Lithuania, Finland, Norway, Poland and Romania. I wish you a successful conference and fruitful discussions during the conference. I hope that we will also find new ideas for further cooperation.

Aret Vooremäe
Director of the Institute of Agricultural and Environmental Sciences,
Estonian University of Life Sciences
Tartu, Estonia

ORAL PRESENTATIONS

In Memory of Dr. Kalju Kask (13.12.1929 – 30.06.2021)

In June 2021, our beloved and highly appreciated fruit breeder, research scientist and *grand old man* dr. Kalju Kask passed away.

Kalju Kask was born in December 13, 1929 in Tallinn, in the capital of Estonia. He became an outstanding researcher on fruits/berries and he was a very fruitful breeder. Literally, the fruits of his work are appreciated probably in most of the Estonian gardens and even abroad. In 1955, he graduated *cum laude* from the Estonian Agricultural Academy. His work with orchards and fruit breeding started in 1956, when he was employed as a gardener by the Institute of Experimental Biology of the Estonian Academy of Sciences. After that he became a researcher while working on fruit breeding and investigating the new fruit and berry cultures. In 1961-1964, Kalju Kask started his postgraduate studies in plant physiology, and had a successful defence of his thesis on the same topic in 1965. This was the time when the construction work of the Tallinn Botanical Garden started, and Kalju accepted the task to create the dendrological collection. In 1970, he headed to continue the fruit breeding done by professor Aleksander Siimon at the Polli experimental station of the Scientific Research Institute of Estonian Agriculture and Amelioration as senior researcher, later as a leading researcher. After 17 years of hard work Kalju Kask obtained a doctoral degree in agricultural sciences in 1974 at Latvian Academy of Agriculture.

His remarkable input and life's work was the breeding of new apple, pear and sweet cherry cultivars. Dr. Kalju Kask has bred 24 apple, 3 pear and 10 sweet cherry cultivars, and 8 of these include other breeders as co-authors. The list of recommended cultivars composed by the pomological committee of Estonian Horticultural Association comprises the apple cultivars 'Krista', 'Katre', 'Liivika', 'Kuku', 'Tiina', 'Lembitu'; pears 'Pepi', 'Kadi'; and sweet cherries 'Meelika', 'Karmel', 'Norri', 'Mupi' and 'Kaspar'. One of the most important traits of the breeding was disease resistance. Kalju bred four apple scab resistant cultivars - 'Ritika' and 'Ruti' (2009), 'Virve' and 'Kalju' (2018). Kalju Kask worked at Polli Horticultural Research Centre until 2009, when he retired.

Dr. Kalju Kask took part in the work of FAO, and with his contribution, the measures for genetic preservation and protection of food plants were developed in 1995. As a team member of the protection of European fruit tree gene banks at FAO, he managed to establish good cooperation and contacts with other gene banks in many countries. For 15 years, Kalju was a team member of genetic resources of Nordic Council of Ministers. He participated actively in the international conferences of fruits and berries, and in horticultural congresses, creating himself a remarkable international network of colleagues and friends. Since 1979, Kalju was a member of the American Pomological Society.

Kalju Kask was also very successful in publishing. He has published up to 1000 articles, including 101 research articles. He has written 14 books, of which in his opinion, the most important was the „Pomology in Estonia. Cultivars and the breeders.", published in 2010. His last and most comprehensive biography entitled „Fruit researcher and breeder" (392 pp.) was published at the end of 2019 for celebrating his 90th birthday.

The outstanding research of Dr. Kalju Kask has gained important recognition: the honorary scientist of the Estonian SSR (1988), Estonian University of Agriculture Badge of Merit (2004), a honorary member of the Academic Agricultural Society, Lifetime Achievement Award (2005), The Order of the White Star (IV Class) (2006), Estonian National Research Award (for outstanding lifetime achievements in research and development) (2009), golden decoration of the Ministry of Agriculture (2010), the honorary citizen of Karksi parish (2010).

Kalju retained his remarkably good memory, broad interest in the world events, great interest in colleagues and in new cultivars until the end of his life. He enjoyed travelling and listening to music, he was interested in art, literature and the history of different cultures. The remembrance of him as a very honoured fruit breeder and scientist will remain with us forever. To conclude with the own words of Dr. Kalju Kask: „A cultivar breeder must have patience. Furthermore, a breeder must have the ability to cope with failures."

Dr. Ave Kikas
Senior researcher/ fruit breeder at Polli Horticultural Research Centre
Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences

Fruit and berry research in Estonia

Ulvi Moor[1*], Kadri Karp[1], Mariana Maante-Kuljus[1], Reelika Rätsep[2,3], Hedi Kaldmäe[2], Ave Kikas[2], Kersti Kahu[2], Toivo Univer[2]

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Abstract

Fruit and berry research at the Estonian University of Life Sciences is conducted by two research teams in two locations – at the Chair of Horticulture in Tartu and at the Polli Horticultural Research Centre in Polli.

Polli Horticultural Research Centre holds the collection of fruit and berry genetic resources since 1945, which includes now up to 1200 accessions. The collection in numbers includes in addition to introduced cultivars, 340 Estonian fruit and berry cultivars in total, of which the 116 have been bred in Polli. The descriptions of cultivars preserved in the collection can be found at https://sordivaramu.emu.ee. The new programme set for 2021-2027 (http://www.genres.ee/en/) is focused on collecting, conservation and using of plant genetic resources for food and agriculture. The current aims for breeding programmes in 2020-2030 are scab resistant apple and pear cultivars, winter hardy sweet cherry and plum cultivars with high yield and fruit quality, and breeding of berry crops (currants, gooseberry, raspberry and blueberry) suitable for local climatic conditions, for organic and conventional cultivation. The breeding and preservation of stone fruits in the frame of 2020-2030 aim at compact tree crown, large fruits, self-fertility, high fruit quality, disease and pest resistance and suitability for Baltic climatic conditions. The breeding of blackcurrant cultivars targets winter hardiness, resistance to mildew and gall mite, but also high yield, fruit quality and machine harvesting are very important. Besides breeding and conservation, development of cultivation and processing technologies for different fruit and berry species and valorisation of plant-based by-products in cooperation with SMEs is of great importance.

In Tartu, the research is conducted in ornamental plants, vegetables and also fruit and berry crops. Several innovative production technologies for the horticultural sector are developed in cooperation with the berry producers. One of the aims has been to prolong strawberry season in Estonia by using high polytunnels and everbearing cultivars. Also, important studies on the effect of irrigation regimes on the yield and fruit quality, sustainable and effective plant protection measures for organic strawberry production (the effect of insect nets, UV-C radiation and plant oils) have been accomplished. In addition to production systems, fruit processing is of great interest. Apple juice quality was studied during four years in terms of health-beneficial polyphenols and health-threatening mycotoxin patulin. The results presented that physiological disorders increase the risk for patulin occurrence in juice and patulin formation in disordered apples may occur even without visual signs of fungal infection. More than ten years, interspecific hybrid grapevine cultivars have been studied at the Chair of Horticulture. 10-year-long data assessment showed that there is a problem with low sugars and high organic acids contents. Tartaric acid content has been at the desirable level but malic acid tends to be high, which gives sharp-sour taste to wine. Therefore, mixing cultivars can be recommended. For example, 'Hasansky Sladky' with high sugar but low anthocyanins content can be mixed with 'Rondo', in which mentioned parameters are reversed.

The future research both in Polli and in Tartu is focused on increasing sustainability of horticultural production systems and better utilization of raw material for instance by valorisation of agricultural and horticultural side- and by-products with the “zero waste” concept.

Evaluation of Estonian apple cultivars and hybrids in Latvia

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Abstract

Estonian apples have always been popular in Latvia. At present, 'Tiina' is widely grown commercially as well as in home gardens, and 'Liivika' is promising for organic and home orchards. Several new selections by breeder Kalju Kask (Polli) are included in field trials at Institute of Horticulture – 'Aule', 'Kastar' and KK 201-2 ('Karlote') since 2011, 'Kersti' since 2014, 'Kelin' (scab resistance gene Rvi6) and KK 2812 since 2015. Their trees were planted on dwarfing rootstock B.9 as one-year-old whips at distances 1.5 x 4 m, in 3 replications with 2 trees in a replication. Commercial cultivars 'Auksis', 'Antei' and 'Zarya Alatau' were used as controls.

The highest productivity had 'Aule' and 'Kastar', the best fruit quality – 'Aule' and 'Kelin'. 'Aule' has been highly esteemed also by some Latvian farmers. Fruits of 'Kelin' had the longest storage, which is crucial for a cultivar's commercial success in Latvia. On the other side, 'Kersti' proved to be unsuitable for Latvian conditions, having very strong tree vigour and low yields. 'Kastar' showed a high tendency to fruit cracking at calyx, while KK 201-2 and KK 2812 had low yields. Of newer acquisitions, scab resistant (gene Rvi6) 'Virve' and KK 4-11 show good preliminary results and will be propagated for trials on dwarfing rootstocks. Productivity, tree characteristics, fruit quality traits and taste panel evaluation of Estonian apples in Latvia will be discussed.

Keywords: *Malus* x *domestica,* productivity, fruit quality, storage, scab resistance

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PPP NORDFRUIT – Pre-breeding for future challenges in Nordic fruit and berries

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Abstract

The project Pre-breeding for future challenges in Nordic fruit and berries (PPP NORDFRUIT) followed two previous PPP projects in apples (NORDAPP), and was operative from 2018 to 2020. In the previous projects carried out by the breeding entities Graminor, SLU and Luke the main aim was to work out protocols for inoculum handling, infection and scoring of resistance to apple diseases. PPP NORDFRUIT included strawberries and strawberry diseases in the pre-breeding work, and participating research institutes from Norway, Denmark and the Baltic countries. The project also included consultative participation from Wageningen Research. NORDFRUIT was a major shift both in resources and participation in order to capitalize results from the previous PPP projects and a first step towards genome-assisted breeding.

The consortium partners agreed on cultivar panels based on importance in production and breeding – a total of 50 cultivars in a core collection and 150 cultivars in a diversity collection for both apples and strawberries. Available samples of these accessions were genotyped by SNP and phenotyped at respective locations for agreed characters. Strawberry seeds from the reconstructed *F. ananassa* (*F. chiloensis* × *F. virginiana*) were provided by J. Davik, NIBIO, and 13 populations from this material were raised at Graminor and Luke. Elite populations of strawberry crossings from Graminor and LUKE were raised at Graminor and planted at both locations in replicated block design in order to get a more diverse genepool for GWAS studies. Hybrid seeds from intercrossing with *Malus sieversii* were produced by Graminor and shared with the other breeding entities.

A total of 217 apple accessions from the consortium partners were genotyped by a SNP 20k Infinum array, and additional 36 accessions from previous analyses by CU-PLEN. The results show relationships of the material and some key genitors of the cultivars were identified. Especially the Eastern material showed to have Transparente Blanche, Antonovka and Liivi Kuldrenett as very important genitors.

Apple GWAS analyses are in progress. As the apple crops have been highly variable during the projects, the project was awarded one year of prolongation especially in order to include more phenotypic data for the

analyses. The most promising results are related to crop earliness. Marker validation for other traits as disease resistance are in progress, too.

In strawberry a total of 726 accessions were successfully genotyped by an Axiom Fana SNP 384k array. A considerable work was carried out at Luke for development of selection methods for *Phytophthora cactorum*. Strawberry was not awarded continuation in the Nordic PPP platform, and the work will be continued in other projects, a.o. in the EU Horizon project BreedingValue.

Several protocols for phenotyping both for diseases, phenology and quality characters have been worked out and shared in the consortium.

Key words: Pre-breeding, apples, strawberries, Nordic collaboration, *Malus x domestica*, *Fragaria x ananassa*

Acknowledgements: This work was financially supported by the Nordic Public-Private Partnership (PPP) for pre-breeding.

Thirty-five years of blackcurrant (*Ribes nigrum* L.) breeding at the National Institute of Horticultural Research in Skierniewice, Poland

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Abstract

Applied breeding of blackcurrant (*Ribes nigrum* L.) cultivars in Poland has a long tradition, but until 1986 it was carried out on a small scale. It was started at the former Institute of Pomology in Skierniewice in the early 1950's by Eng. Kazimierz Somorowski. In the years 1968–1985 breeding work on this species was continued by Dr. Józef Gwozdecki at the former Institute of Pomology and Floriculture in Skierniewice, their effect was two cvs. 'Bona' and 'Ceres'. Since 1986, the blackcurrant breeding program has been conducted at the Department of Horticultural Crop Breeding of the National Institute of Horticultural Research (INHORT) by Assoc. Prof. Stanislaw Pluta (with the Team) financed from the state budget by the Ministry of Agriculture and Rural Development. Our blackcurrant breeding goals coincide with the assumptions that are implemented in other global breeding centers of this species. This program includes breeding for resistance, fruit quality and adaptation. Newly bred cultivars should be characterized by high productivity, good suitability for various methods of fruit management (processing, freezing, fresh consumption), good adaptation to Polish climatic and soil conditions and various cultivation technologies - industrial cultivars for picking fruits by different harvesters and dessert cultivars for trellising crop cultivation. In addition, new cultivars should be less susceptible or resistant to the most dangerous diseases and pests.

Traditional cross breeding is a method in which the flowers of selected parental forms (genotypes) are pollinated in a controlled manner, fruits are harvested from pollination and seeds are extracted. Then, seedlings (hybrids) of the F_1 generation are produced, the population of fruiting plants resulting from these seedlings is assessed and the best individuals are selected. In the next stage, they are vegetative propagated and planted in a collection as well as in cultivar trails to perform a full assessment. The best of them are submitted for registration tests at the Research Center for Cultivar Testing (COBORU). The entire breeding process, from crossing to release new cultivar takes usually 10-12, sometimes 15 years.

During the 35 years of breeding work, 10 blackcurrant cultivars ('Tisel', 'Tiben', 'Ores', 'Ruben', 'Tines', 'Gofert', 'Polares', 'Tihope', Polben 'and' Polonus ') were released at the INHORT in Skierniewice and they are in the national register in the COBORU. Most of these cultivars are also covered by Community protection law within the territory of the EU countries. In addition, three cvs. ('Gofert', 'Polares' and 'Tihope') obtained the plant patent in the US in 2016.

Polish blackcurrant cultivars have gained great recognition among Polish and foreign growers. The available data show that the share of Polish cultivars in commercial plantations in our country is currently over 80%, with the majority (about 50%) being the cv. 'Tisel'. Blackcurrant cultivars bred at the INHORT in Skierniewice and implemented for the fruit production are an important carrier of biological progress, which contribute to possess the high position and competitiveness of Polish horticulture while maintaining environmental protection requirements and the principles of safe food production, in accordance with the current EU requirements.

Keywords: blackcurrant, *Ribes nigrum* L., breeding method, goals, achievements

Apple scab control in organic apple orchards

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Abstract

Scab caused by *Venturia inaequalis* (Cke.) Wint. is the main disease of apple. Most cultivars are highly susceptible, and losses directly attributable to the disease can compromise entire harvests unless protective treatments are applied. The conventional approach is to apply fungicides regularly from the start of bud break (in March-April) until just before harvest. Accurate prediction of the potential for infection and inoculum availability is critical to prevent infections during the primary period for apple scab. Several applications depend on cultivar susceptibility, weather conditions, and the amount of inoculum.

In apple orchards, the use of pesticides is high compared to other crops. In integrated pest management (IPM) apple orchards in Latvia, 6–12 sprays are commonly applied against apple scab each season. Over the past decade, public concern about pesticide residues on fruit and in the environment is increasing and interest is growing in organic apples. Apples are among the most difficult crops to grow organically. Without effective management of apple scab the yield will likely be low and of poor quality. To search for solutions to ensure the quality of apples, the Institute for Plant Protection Research "Agrihorts" in three years in cooperation with Latvian fruit growers carried out a demonstration trials to control apple scab in an organic apple orchards. Plant protection strategy was based on usage of inorganic compounds like copper, sulfur, lime sulfur, and potassium bicarbonate following decision support system RIMpro warning signals.

The incidence level of apple scab was highest in the control plot during the 2020 vegetation season, reaching 96%, while in the inorganic compounds-treated demonstration plot, the incidence was 16%. In the first two years of the experiment, the prevalence of scab was generally lower, but it was always higher in the control plot than in the demonstration plot.

The effect of *Lamiaceae* plants essential oils on fungal plant pathogens *in vitro*

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Abstract

Fungal pathogens *Alternaria* spp., *Botrytis* spp. and *Colletotrichum* spp. cause a significant loss of horticultural crops and their yield annually. The most convenient way for controlling diseases caused by these pathogens, is the use of chemical fungicides, which are harmful to the environment and humans. Therefore, there is a growing demand for a natural source of active ingredients from plants. The findings of antimicrobial and antifungal activities, low toxicity, and biodegradability of essential oils make them potential for use in plant protection against pathogens instead of chemicals.

The purpose of this research was to evaluate the ability of essential oils from *Lamiaceae* plants to suppress the growth of *Alternaria* spp., *Botrytis cinerea*, and *Colletotrichum* spp. The study was carried out at the LAMMC Institute of Horticulture, Lithuania. Essential oils from lavender (*Lavandula angustifolia*) and thyme (*Thymus vulgaris*) were obtained by hydrodistillation. Collected oils poured to potato dextrose agar medium at 200-1000 µL/L concentrations. The radial colony growth of each pathogen was measured after placing mycelial plugs of each fungus on Petri dishes.

Results demonstrated that thyme essential oil significantly suppressed the growth of all three investigated fungal pathogens at 7 days after inoculation as no growth of the pathogens was observed. Meanwhile, lavender essential oil had lower antifungal activity than thyme.

To conclude, thyme essential oil showed high antifungal activity, and lavender essential oil showed moderate antifungal activity. Both oils can be applied as one of the eco-friendly ways to control plant pathogens.

Keywords: antifungal, essential oils, fungal pathogens, *Lavandula angustifolia, Thymus vulgaris*.

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Precision fertilisation technology for berry cultivation on plantations

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Abstract

Increased cost-effectiveness in crop production cab be achieved with automating the technological operations, it is true also for berry cultivation on plantations. It is rational to start the automation process of berry cultivation with fertilising, since this is the first and relatively simple technological operation during the vegetation period with the main task to apply the correct fertiliser amount under the canopy of plants. Blueberry plantations established on milled peat fields have plants planted in parallel rows at the designated step. The fertilisation of plants must take place individually in the first years of their growth, i.e. each plant is fertilised separately. This kind of fertilising can be called precision fertilisation. Aim of this paper was to give an overview of the state of the art of precision fertiliser equipment and to introduce the concept of a new precision fertiliser robot with the justification of the robot use efficiency. The fertiliser robot to be designed is autonomous, will move unmanned in the plantation, and will include necessary sub-systems for individual plant precision fertilisation like plat detection system, fertilising nosel motion system and in addition a service station.

Keywords: berry plantation, agricultural robotics, precision fertilisation, product design and development.

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Mining profitable nutrients from fruit processing by-products and waste - The Lithuanian perspective

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Abstract

According to the FAO, roughly one-third of edible agro-food materials for human nutrition is lost or wasted, while the fraction of waste in fruit chain may reach up to 45%. In general, processing of agro-food materials, besides the main product stream, almost always generates by-products, which nowadays in many production chains are used inefficiently or discarded as a waste, causing environmental problems and nutrient's loss. Therefore, there is an urgent need for developing effective, preferably 'zero waste', schemes for biorefining by-products into higher value ingredients.

A large selection of established and emerging technologies is available for this purpose, including various extraction, fractionation, separation and purification techniques. The application of the recovered substances depends on their composition, purity, properties and costs, which are, as a rule, increasing with every additional process. Thus, estimating the ‚golden mean' has become an essential issue in commercialization of recently developed technologies. Many small fruit species (commonly called berries) are known for their excellent flavor and healthy phytochemicals. However, due to a rapid decay the major parts of berry crops are processed into longer shelf-life products. For instance, pressing juice results in large quantities of by-products, which are rich in valuable phytochemical compounds and other nutrients; however, currently they are used for animal feeding and composting or even discarded as a waste, mainly due to a lack of scientific, technological and economic valorization studies. Considering the existing challenges, R&D activities have been substantially expanded in Lithuania during the last years in order to increase the value of berry processing by-products.

The work performed by far revealed that various integrated biorefining schemes for processing berry pomace into high value ingredients may be developed by using supercritical CO_2 (Sc-CO_2), conventional, pressurized liquid, ultrasound and enzyme assisted extraction and fractionation methods. Valuable substances have been recovered from berry pomace by their combination. For instance, Sc-CO_2 recovered lipophilic fractions are rich in polyunsaturated fatty acids, tocopherols, phytosterols and some other compounds: at optimized parameters the yields are in a wide range, from 3% (chokeberry) to 25% in (guelder-rose berry). Other substances may be further recovered from the defatted residues by using various methods. The selection of the processes/methods depends on berry type and extraction parameters and may produce 20-60% of soluble fractions.

The composition of fractions was analyzed by chromatography with various spectroscopic detectors, while bioactivities were evaluated by various in vitro chemical and cellular assays. The results have proved the presence of valuable bioactives in pomace fractions, which may be used in functional foods and nutraceuticals. For instance, strong antioxidants recovered from raspberry, chokeberry and cranberry pomace improved oxidative and microbiological stability of meat products. Moreover, it is hypothesized that berry phytochemicals might mitigate adverse effects (carcinogenicity) of processed meat products to human health. Preliminary studies of such effects on cancer cells were performed using in vitro digestion models.

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Research on fruit and berry by-product valorisation in Estonia

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Abstract

The valorisation of agri-food by-products and wastes is gaining impetus worldwide in terms of decreasing the CO_2 footprint and circular economy principles. Consumers demand for science proved, healthy and tasty food products with low content or no synthetic food additives is one of the drivers in search for alternatives. Many of the research projects undertaken at the Estonian University of Life Sciences are targeted to resolve these issues regarding the reduction of food waste and loss by better valorisation of by-products.

The project „PlantValor – a full-scale product development service in synergy with the traditional activities of the Polli Horticultural Research Centre “, creates the base for the activities in the field of fruit and berry research, product development, and by-product valorisation. Polli Horticultural Research Centre has 50 ha of experimental orchards, approved primary processing unit and the Competence Centre for Knowledge-Based Health Goods and Natural Products, which all serve the purpose of better crop yield, quality and valorisation of the plant-based products. The R&D activities are supported by the modern high-technology methods and laboratory infrastructure in combination with multidisciplinary research staff.

Various plant production and processing residues, which contain bioactive compounds with the potential to inhibit the growth of spoilage and pathogenic microorganisms and the oxidation of fatty acids and cholesterol, could be more exploited. The ResTA14 project “TAIMLOOMTOIT” is determined to implement complex research in order to find out the potential of selected plant materials (apple, rowanberry, chokeberry, blackcurrant, tomato, rhubarb, garlic, onion etc) for the enrichment of Estonian local fish and meat products. The addition of fruit and berry powder mixtures has shown promising results on inhibiting the microbial growth and oxidation processes in raw and processed minced meat balls. The next step will comprise the optimisation of fruit and berry extraction technologies and meat product prototypes containing the value-adding extracts.

The ERA Chair for Food (By-) Products Valorisation Technologies (VALORTECH) of the Estonian University of Life Sciences was established to tackle the problems of agri-food by-products and wastes and to apply the zero waste concepts in the Estonian agri-food sector. So far, the research undertaken by VALORTECH researchers has been focused on using green extraction technologies for the recovery of bioactive compounds (antioxidants, pigments etc) from pumpkin peels, sea-buckthorn pomace, gooseberries and Estonian winery waste (rhubarb, Japanese quince, chokeberry and grapevine). In addition, dietary fibre, amino acids and other nutritionally valuable compounds from sea-buckthorn pomace have been explored for animal feed or for the production of bioplastics from rapeseed cake to make better use of the by-products.

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Cranberry presscake as a source of valuable compounds

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Abstract

Cranberry pomace is a by-product of cranberry juice production and is comprised of seeds, skins and stems of the fruit. It was determined that berry seeds contain high levels of valuable lipohilic compounds, while the skins are rich in polyphenolic phytochemicals, particularly anthocyanins, flavonols, and procyanidins. For this reason, the number of studies on recovery of bioactive components from different fruit waste has been regularly increasing. In recent years such innovative methods as supercritical fluid extraction with carbon dioxide (SFE-CO_2) and pressurized liquid extraction (PLE) has gain the popularity in isolating bioactive compounds from berry pomace. The aim of this work was to develop multi-step biorefining scheme for valorizing cranberry pomace as a source of valuable nutrients by using SFE and PLE processes and characterize the extracts.

Extract properties were evaluated by using *in vitro* antioxidant capacity assays (ABTS radical cation scavenging, oxygen radical absorbance capacity assay (ORAC) and *Folin-Ciocalteu* method), while their composition was analysed by ultra-performance liquid chromatography (UPLC) for triacylglycerols (TAGs), sterols, polyphenols, mainly anthocyanins, content; high performance liquid chromatographic (HPLC) for β-carotene content; gas chromatography (GC) for fatty acids composition and spectrophotometric methods for total carotenoids and proanthocyanidins content in extracts.

The yield of lipophilic fraction recovered by SFE-CO_2 was 11.10%; linoleic, oleic and linolenic acids were major in the extracted oil; consequently, highly unsaturated triacylglycerols (TAGs) were major lipids found in the extract. The LLLn constituted 22.19%, OLnL- 21.88%, LLnLn-13.56 and OLL-15.40%. The total content of carotenoids was 11.98 mg β-carotene/100g extract, while β-carotene content was 3.48 mg/100g extract. Four tocopherols and phytosterols were preliminary quantified by their peak area; α-ocopherol was dominating in cranberry pomace oil, while the content of β-sitosterol was many times higher than the content of other detected sterols (stigmasterol, ergosterol, and cholestan-3-ol). Deffated cranberry pomace further was sequentially extracted with ethanol and water by PLE. The yield of ethanol extract was 55.89%, while water additionally recovered 6.50% of extract.

The highest recovery of proanthocyanidins (532.2 mg/100g extract) was achieved with water as a solvent. Among 6 quantified by UPLC-MS/MS anthocyanins, peonidin-3-galactoside was the major constituent, followed by peonidin-3-arabinoside in both extracts. Phytochemical composition of defatted cranberry pomace extracts showed that malic, quinic, citric, chlorogenic acids were present in both extracts, while the most quantitatively important bioactive compounds in defatted by SFE-CO_2 cranberry pomace ethanol extract (in mg /100 g extrtact) were quinic acid (572.9), chlorogenic acid (88.6) and catechin (60.3). The antioxidant capacity of pomace extracts measured by different methods increased with increasing solvent polarity. It may be concluded that the lipophilic and hydrophilic extracts isolated from dried cranberry pomace by supercritical CO_2 and pressurized liquid extractions are a good source of bioactive compounds, which might find applications in the formulation of functional foods and nutraceuticals.

Biologically active compounds composition of wild bilberries (*Vaccinium myrtillus L.*) – effects of geographic origin

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Abstract

The authenticity and traceability are very important criterions of product quality. In order to assure quality, the chemometric approach can be efficiently used for berries and their products quality and authenticity. Phenolic compounds are the major group of phytochemicals found in berries. The aim of this study was to evaluate the variability of the biologically active compounds of wild bilberry (*V. myrtillus L.*) samples collected from 3 different locations in Norway (NOR), Finland (FIN), Latvia (LVA) and Lithuania (LTU) were analyzed.

The berries of bilberries were handpicked during the summers of 2019 and 2020 at the time periods when they are typically harvested for commercial purposes in Northern Europe. Using HPLC-DAD, 15 anthocyanins were identified in bilberries, as well as develop tools for the authenticity and quality control of wild bilberries in different geographical location. The contents of the individual anthocyanin glycosides were significantly different between the countries. In bilberries from NOR and FIN the major anthocyanin was Dp-3-ara (13.7-16.0% of total anthocyanins), followed by Dp-3-gal (11.6-14.0% of total anthocyanins) and Dp-3-glc (11.0-13.6% of total anthocyanins). In bilberries from LTV and LTU the major anthocyanin was Cy-3-glc (12.9-14.4% of total anthocyanins), followed by Cy-3-gal (10.5-14.0% of total anthocyanins) and Dp-3-glc (10.8-12.7% of total anthocyanins). 2019-2020 years of investigation bilberries from LTV and LTU had significantly lower contents of Dp-3-gal and Dp-3-glc than berries from NOR and FIN, but higher contents of Pn-3-glc. Results indicated geomorphological influence on the biochemical composition of bilberries depending on their origin.

Keywords: wild bilberry; bioactive compounds, anthocyanins, different geographical locations

Influence of apple varieties and microflora diversity on the sensory and volatile profiles of apple cider

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Abstract
In recent years, cider has become very popular among consumers, and global cider production is constantly growing. Sensory qualities are the decisive factor in consumer preferences; therefore, alcoholic and malolactic fermentation require special attention. Apple variety and the maturity of the fruit are the significant attributes that influence the volatile composition of cider.

This study aims to summarize and synthesize the apple varieties that are suitable for obtaining cider, biotechnological stages of alcoholic and malolactic fermentation, as well as the types of microorganisms involved in these processes.

The recent literature was reviewed by searching the following databases: Web of Science, Science Direct, Scopus and Google Scholar, using specific descriptors and keywords.

Each type of yeast involved in the fermentation process obtains different sensory characteristics in the finished product. Co-fermentations also play an essential role in the diversity of flavour compounds. The critical step in the formation of volatile compounds and the definition of flavours is malolactic fermentation. As the primary role, the transformation of malic acid into lactic acid takes place under the action of different types of microorganisms.

There are various researches conducted to improve the quality and production of cider which is increasingly popular. Therefore, the diversity of the microflora involved in the fermentation processes influences the variety of volatile and polyphenolic compounds.

Keywords: cider production, fermentation, volatile compounds, phenolic compounds

Novel and hybrid technologies for the valorization of blackcurrant press-cake: from the biorefinery concept towards added-value snack products (PowerXtract and ReLoVeD projects)

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Abstract

Blackcurrant juice processing is popular throughout Europe, while Poland, Ukraine and United Kingdom being the largest berry producers. It is widely known that blackcurrant contains some beneficial compounds on the human health, and therefore its processing concept has to be very refined to benefit the most from the added-value of the berry. The compounds of interest in the blackcurrant press-cake are the dietary fiber, anthocyanins, and flavonols along with fats and proteins. Some of these were shown good antioxidant, cardioprotective, antiviral, antibacterial, and anticancer activities based on pre-clinical studies. For this reason, they serve a good base to produce functional foods. After the juice pressing, approximately 25 % of the original mass weight remains as the remaining press-cake, and it can be valorized in a biorefinery concept since it contains different bioactive compounds with health benefits to a great extent.

In this work we suggest a biorefinery concept for the valorization of blackcurrant press-cake in a multistage processing, including enzymatic pre-treatment of the press-cake to enhance the liberation of the anthocyanins, flavonols, and other phenolic compounds. These enzymes can be different in their nature of action, they can act on pectin, cellulose, or on non-starch polysaccharides.

Once the structure of the press-cake is broken, novel extraction technology is used to recover the valuable compounds with a solvent, e.g., acidified ethanol solution or water. Different novel extraction technologies were compared including microwave-assisted extraction, ultrasound-assisted extraction, and pressurized hot water extraction for efficiency in terms of total phenol content and monomeric anthocyanins. Usually, these extracts are very low in concentration of the target compounds, and therefore they can undergo a concentration process using the combination of pressure and concentration driven membrane processes. The final step of the production of value-added fraction is spray-drying or freeze drying.

Different model foods can be designed with the dried techno- and bio functional ingredient to increase the availability of the health promoting compounds in a diet. In addition to these, we increase functionality of the products by adding extract from spruce needle (*Picea abies*), which is known to exert e.g., antimicrobial and antioxidant properties.

The remaining exhausted press-cake are tested as an additional material in established end-of-the-pipe technologies to produce chemicals or energy, and therefore close the loop of the biorefinery.

POSTER PRESENTATIONS

Collection, identification and characterization of fruit crop genetic resources in Latvia

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Abstract

Genetic resources are essential for fruit crops to constantly evolve and develop due to new challenges such as climate change, the spread of diseases and pests, and consumer expectations; they are also an important part of national heritage. Currently, more competitive cultivars are replacing old, traditionally grown ones in commercial fruit-growing. However, their adaptation and plasticity to future challenges may be limited, threatening the crop as a whole. Therefore, identifying and *ex situ* conserving genetic resources that occur *in situ* (wild species and wild relatives) and *on-farm* (orchards) is necessary, as these samples represent the results of a long-term adaptation process and are threatened with extinction.

The aim of the study - to evaluate the situation on plant genetic resources grown *in situ* and *on farm* in Latvia, collect samples through expeditions, describe them using available descriptors, including into field collections of the Institute of Horticulture – part of the National plant genetic resources system.

The evaluation of fruit genetic resources involved professional and amateur growers, horticultural collectors, and fruit-growing activists. The obtained information was used to localize sampling sites, initial identification and assessment of potential candidates for genetic resources. The collection expeditions have been carried, covering all regions of Latvia. As a result, 68 fruit crop samples were collected and submitted for further evaluation (26 sweet cherry, 14 apple, 13 *Viburnum*, 11 domestic plum, three sour cherry and one gooseberry accession).

Simultaneously with the evaluation of the newly collected samples, the evaluation of the existing germplasm was also performed using descriptor lists. Characterization and evaluation descriptors are a list of traits developed for each species, describing samples of the species using morphological and agronomic traits. The description of one sample must be repeated for at least three years, as many characteristics are also affected by environmental conditions. As part of the study, such descriptions were done for 125 apples, 13 sweet cherry and ten sour cherry accessions, using 44, 75 and 75 traits, respectively. Descriptor data will be used to select samples with necessary specific characteristics, register local varieties, confirm their identity. Fruit plant species for which descriptors are not available are also surveyed and collected from local genetic resources.

Therefore, in the frame of the study, a descriptor list was developed for black elderberry (*Sambucus* sp.). The implementation of the study will provide an opportunity to identify and conserve Latvia's plant genetic resources, develop recommendations for further *in situ* and *on farm* conservation, and ensure the sustainable use of genetic resources. The study was supported by the Ministry of Agriculture, project No. 20-00-SOINV05-000016 "Identification, collection and research of the potential genetic resources of food and agricultural plants and their wild relatives grown in situ in Latvia".

Keywords: germplasm, fruit crops, *ex situ*, on farm, conservation

Preliminary results of five sweet cherry rootstock evaluation for Estonian cultivar 'Anu'

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Abstract

One of the most important preconditions for the establishment of productive sweet cherry orchards is the right choice of rootstock suitable for local climatic conditions. *P. maheleb* is more widely used rootstock for sweet cherries in Latvia, however it has several disadvantages - strong vigour of grafted trees and unsuitability for heavy, waterlogged soils. The aim of the study is to test the suitability of sweet cherry rootstocks of different origins for winterhard cultivar in Latvian climate.

The trial was established in 2014 at the Institute of Horticulture (LatHort) to test four clonal rootstocks: 'Piku 1', PHL-A', 'Gisela 5', 'VSL 1', and generative rootstock *P. mahaleb* (control) in the combination with cultivar 'Anu' (Estonian breeding). Cherries were planted at the distances of 5×3.5 m in random block design in three replications with three trees per plot. Tree height, annual growth of shoots, the viability of trees after wintering period and the intensity of flowering and production were evaluated. According to the results of the first five evaluation years, the highest viability of trees as well as the highest intensity of flowering and production were observed for trees grafted on 'Gisela 5'. The trees on 'VSL-1' had highest decease rate and lowest winter hardiness.

Keywords: *P. avium*, compatibility, winter-hardiness, flowering, rootstocks

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Influence of Raspberry bushy dwarf virus on pollination of red raspberry (*Rubus idaeus* L.) cultivars

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Abstract
Raspberry bushy dwarf virus (RBDV) is one of the major pollen-borne pathogens of the genus *Rubus*, that causes drastic reduction of yield and degradation of berry quality. The aim of the study was to evaluate the quality of raspberry pollen and the effect of RBDV on pollination process. The research was carried out at the Institute of Horticulture. Within two years, 2017 and 2018, the pollen viability and pollen germination capacity of nine raspberry cultivars were analysed. The cross-pollination was done and the pollination quality of 31 crossing combinations was evaluated.

The study found that although the pollen viability of cultivars infected with RBDV was higher than that of uninfected cultivars, there were no statistically significant differences. The viral contamination of the mother plant played a more important role in the pollination process. Pollination was better on uninfected mother plants and pollen germinated was faster than on infected plants. However, when the virus-infected cultivars were pollinated with infected pollen, the virus had an effect on the growth rate of pollen tubes, that decreased and the pollen tubes did not reach the ovary.

Key words: Pollen germination, pollen viability, hybridization, fluorescence microscopy

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Influence of vermicompost on strawberry plant growth and dehydrogenase activity in soil

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Abstract

Vermicompost is increasingly becoming popular as an organic fertiliser used for different crops. Effects of vermicompost on strawberry plant growth and soil properties were studied in this investigation. The research was performed in LatHort from 2015 to 2017. Strawberry was grown on open field in rows. Two trials were established. In Trial 1, the application of vermicompost with a dose of 50 mL per plant was compared to growing without any fertilization. In Trial 2, several treatments were used: 1) only inorganic mineral fertilization applied; 2) vermicompost applied with a dose of 100 mL per plant in planting holes, later mineral fertilization applied; 3) vermicompost applied with a dose of 100 mL per plant in planting holes, no additional fertilization applied; 4) vermicompost applied two times per season on the ground around plants with dose of 50 mL per plant, no mineral fertilization applied. The plant growth was assessed two times per season by evaluating the amount of leaves and plant height. Soil dehydrogenase activity was evaluated during all growing seasons as indicator of soil microbial activity. The application of vermicompost positively influenced plant growth in comparison to growing without fertilization. In Trial 2, plant growth varied among years. During first two growing seasons better plant growth was observed for plants fertilized by inorganic mineral fertilizers, while later the growth levelled off for all treatments applied. The application of vermicompost had positive influence on the soil dehydrogenase activity in contrary to fertilization by mineral fertilizers.

Keywords: *Fragaria* × *ananassa* Duch., fertilization, vegetative growth, dehydrogenase activity.

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Effect of rootstock on the growth and early yield of the apple cultivar ‘Sinap Orlovski’

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Abstract

The effect of different rootstocks on tree vigour and early yield of the apple cultivar ‘Sinap Orlovski’ was studied in 2016–2020 at two experiment sites: the Polli Horticultural Research Centre, Institute of Agricultural and Environmental Sciences, Estonian University of Life Sciences, and Tedrearu farm (both on loamy clay soil). Growth and yield parameters were measured for ‘Sinap Orlovski’ trees on dwarf (B9, B396, Pure 1, MTT 1, P 59) and semi-dwarf rootstocks (M26, E28, nine new clonal rootstocks bred in Estonia). The ‘Sinap Orlovski’ trees on dwarf rootstocks already flowered in the nursery and bore fruit on the first year in the orchard. The trees on semi-dwarf rootstocks began to bear fruit later, on the third or fourth year in the orchard. Of the new rootstocks, 82-8-7 and 83-2-1 had the highest yield in a young orchard.

Evaluation of the main biological and production traits of Latvian apple cultivars in the conditions of Central Russia

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Abstract

The studies were carried out in the central zone of Russia in the oldest pomological institution - the Russian Research Institute of Fruit Crop Breeding (Orel region) and the Institute of Horticulture (Latvia). The beginning of the creation of the apple tree gene pool at the Institute dates back to the end of the 19th century, when the acclimatization and introduction of fruit and ornamental plants began and for the first time 44 apple cultivars from North America were imported to Russia including the Orel nursery. Currently, the apple gene pool at the Institute has 880 cultivars collected from various ecological and geographical regions. The preserved apple gene pool is constantly replenished due to new forms from domestic and foreign scientific institutions, including from the Baltic countries, and is the main resource for the creation of new cultivars. The aim of the study was to evaluate the winter hardiness of Latvian cultivars and hybrids by use of modelling of the components of winter hardiness, as well as their productivity, disease resistance, fruit quality and storage, and to select cultivars suitable for use in further breeding.

As a result of the research, the data of a long-term study of the main economic and biological features of apple cultivars and hybrids of Latvian breeding are summarized. From 1980 to 2019, 32 cultivars and hybrids were evaluated using generally accepted methods of cultivar study of fruit crops and the method of modeling damaging factors of the autumn-winter period. The potential of stability of the tissues of the studied apple cultivars in terms of frost resistance components was revealed. The best apple cultivars for use in breeding were selected.

After long-term evaluation, the following can be recommended for use in breeding of scab resistant cultivars with high quality fruits - ‘Dace’ (gene *Rvi6*), ‘Arona’, and good storage - ‘Edite’ (*Rvi6*), ‘Forele’, ‘Olga’, ‘Madona’, for breeding of early cultivars - ‘Roberts’ and DI-93-4-8, both resistant to scab (gene *Rvi6*) and fruit rots. Cultivars and hybrids with the best cold resistance of vital tissues were selected by artificially modelling winter-hardiness components – early colds (1st component) and mid-winter colds to −38°C (2nd component), showing reversible damages not exceeding 2.0 points: ‘Daina’, ‘Ella’, ‘Atmoda’, ‘Gita’, ‘Saiva’, of which the last 3 maintained high hardiness of bark, cambium and xylem with slight increase of bud damages also at −40°C. Cultivars ‘Daina’ and ‘Ella’ showed resistance of buds and vital tissues on the level of ‘Antonovka’ after modelling thaw with following freezing to −25°C (3rd component). These cultivars demonstrated good adaptation to different environment conditions and may be considered in breeding of new adaptive apple cultivars with high fruit quality.

Keywords: winter hardiness, disease resistance, productivity, fruit quality, storage, breeding.

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Suitability of blue honeysuckle (*Lonicera caerula* L.) cultivars for cultivation in the Nordic – Baltic climate

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Abstract

There is a rising trend of blue honeysuckle production, new plantations have been established in recent years in Nordic-Baltic region and in Estonia. This culture is naturally distributed in the temperate climate zone of Northern Hemisphere. Estonia is also located in the same climate but it is differed by warm maritime air.

The main aim of this research was to determine which cultivars are more adapted to the changing weather conditions and have good winter hardiness, high fruit mass, high yield and low occurrence of secondary flowering. The data was recorded from two closely situated plantations in Polli village, Viljandi county, Estonia. 18 cultivars originated from Russia, Canada, Poland and Czech Republic were tested.

In 2016 greater winter damages were recorded when compared to the period 2017-2019 with just marginal damages. The cultivars 'Borealis', 'Duet', 'Indigo Gem', 'Indigo Treat' and 'Tundra' presented their best properties according to the results of winter hardiness, secondary flowering and productivity. In conclusion, it seems that Canadian cultivars are better suited to Estonian climate.

Keywords: Blue honeysuckle, *Lonicera caerulea***,** winter hardiness, secondary flowering, production, fruit mass

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Comparison of Polyphenols Content of Different Blackcurrant (*Ribes nigrum* L.) Cultivars at the Polli Horticultural Research Centre in Estonia

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Abstract

The evaluation of blackcurrant cultivars and their fruit properties at the Polli Horticultural Research Centre has been active since 1945. In addition to assessment of economic-biological properties of cultivars, it is essential to pay attention to fruit quality. In 2014, the laboratory building of Polli Horticultural Research Centre was reconstructed within the PlantValor competence centre project enabling to introduce and validate HPLC methods for the determination of polyphenolic compounds in fruit quality analysis. In 2017 and 2018, the fruit quality of 27 blackcurrant cultivars of different geographical origin (Belarus, Scotland, Finland, Latvia, Lithuania, Norway, Poland, Russia, Sweden, Ukraine and Estonia) was analysed. All cultivars were grown in the genetic resources collection (2008-2019) located at the Polli Horticultural Research Centre. The main aim was to analyse the content of polyphenols and anthocyanins in order to select suitable blackcurrant genotypes for plant breeding and production. For two consecutive years of the study, the total polyphenols content in the fruits of different cultivars varied from 251 to 697 mg/ 100 g and the anthocyanins from 153 to 490 mg/ 100 g.

Keywords: anthocyanins, biochemical composition, blackcurrant, fruit quality, polyphenols.

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Ascorbic acid, phenolic compounds and antioxidant capacity of traditional Serbian 'Plum cake'

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Abstract

The plum (*Prunus domestica* L.) is one of the most widespread fruit crop in the Republic of Serbia, especially in the regions of central and western Serbia. The Republic of Serbia is one of the largest producers of plums in the world and it could be said that plum is one of the symbols of the state. The plum is mostly used for processing into a traditional plum alcoholic drink called 'šljivovica' while smaller amounts are consumed in raw state, dried or processed in jams. 'Plum cake' (šljivani kolač) is form of traditional home-made sweets. The aim of this study was to evaluate content of L-ascorbic acid, phenolic compouns and antioxidant activity of 'plum cake' extract with or without added chopped walnut kernels.

Ten kilograms of ripe plum fruits clean of bones were ground in a mill and cooked for several hours without addition of sugar. At the end of process, 100 g of flour was added, mixed and split into two same parts. In one part 500 g of chopped walnut kernels was added. One cm thick mixtures were dried at sunny and ventilated place for additional seven days. Plant material (1 g) was extracted with 70% aqueous acetone solution (10 mL) by sonication for 20 minutes in an ultrasonic bath at ambient temperature. All extractions and measurements were performed in triplicate. The extracts were centrifuged and filtered and kept refrigerated until assayed. Content of L-ascorbic acid (AA) and phenolic compounds: total phenolics (TP), tannins (TT), flavonoids (TF), anthocyanins (TA) and flavan-3-ols (F3ol) were measured in 'plum cake' extracts. Additionally, antioxidant capacity of extracts were estimated by seven different assays: DPPH (2,2-diphenyl-1-picrylhydrazyl), FRAP (ferric-reducing antioxidant power), ABTS (2,2′-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid)), TAA (total antioxidant activity), TRC (total reduction capacity), NBT (nitroblue tetrazolim or SOD-mimetic) and inhibition of NO radical production.

Although mixture was heated at high temperature for several hours 'plum cake' samples contained significant amount of L-ascorbic acid: 0.113 mgAA/100g in samples without added walnuts and 0.233 mgAA/100g in samples with walnuts.

Both samples of 'plum cake' are high in ascorbic acid and phenolics content and possess strong antioxidant activity. 'Plum cake' with added chopped walnut kernels had the higher content of L-ascorbic acid, TP, TT, TF and F3ol content and manifested stronger antioxidant activity. 'Plum cake' without walnuts possessed higher concentration of TA. Results of this study indicate that 'plum cake' is rich source of bioactive compounds and nutraceuticals and could be excellent product for preserving plums for period of several months without addition of sugars or artificial preservatives.

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Comparison of vitamin C content of blackberry (*Rubus fruticosus* L.) and cornelian cherry (*Cornus mas* L.) from eastern and western Serbia

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Abstract

The term 'red fruits' is used to name the small fruits, sweet or bitter, and intensely colored (usually red, purple or blue) that grow in wild bushes or forests. The interest on the phytochemicals and secondary metabolites in wild-growing fruits increased during past few decades. Numerous studies have revealed antioxidant, antimicrobial, protective and curative activities of different phytochemicals presented in wild-growing fruits. Antioxidants are chemical compounds that inhibit oxidation process be preventing the formation of harmful free radicals in cells. Red fruits are also considered as one of the best food sources of vitamin C (L-ascorbic acid). It functions as a redox buffer which can reduce, and thereby neutralize, reactive oxygen species. The aim of this study was to determine and compare whether certain species of red fruits (blackberry and cornelian cherry) thrive better in the area of western or eastern Serbia, when it comes to the content of vitamin C in these species.

Samples of blackberry and cornelian cherry were collected in a full stage of ripening, both in the western and eastern mountains of Serbia. Vitamin C was determined according to a method by Biswas & Mannan (1996) and it was expressed as mg vitamin C /100 g fresh weight (mg vit C / 100 g FW). The higher level of vitamin C was in both species from western mountains comparing with the same species from eastern mountains. Blackberries from the west (215 mg vit C / 100 g FW) had a higher content of vitamin C than blackberries from the east (0.192 mg vit C / 100 g FW). The cornelian cherry from the western mountain (201 mg vit C / 100 g FW) also had a higher content than the cornelian cherry from the east (170 mg vit C / 100 g FW).

Based on this research, we conclude that both species are rich in vitamin C and that the results are uniform, ie that they are not statistically significant when it comes to comparing the results from the eastern and western mountains. According to the literature data, the results are consistent with the compared literature data for these species when it comes to vitamin C content.

Keywords: vitamic C, blackberry, cornelian cherry, red fruits

Green synthesis of silver nanoparticles using aqueous extract of *Viburnum Zarnica- 2* and *Viburnum Sargentii* berries antioxidant, antimicrobial activity and phenolic composition

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Abstract

Green synthesis provides advancement over chemical and physical methods as it is cost effective, environment friendly, and no need to use high pressure, temperature and toxic chemicals. The aim of this study was designed to synthesize silver nanoparticles (AgNPs) using aqueous extract of *Viburnum Zarnica- 2* and *Viburnum Sargentii* berries.

For investigation were selected two species of *Viburnum Zarnica- 2* and *Viburnum Sargentii* berries. The morphology of particle size of the synthesized AgNPs were carried out by using TEM microscope. Antioxidant activity was tested by different methods such as ABTS, $TFPH^{\bullet+}$, DPPH•, CUPRAC and FRAP assay. Also, spectrophotometric studies were used to determination of phytochemical structure. The antimicrobial activity was investigated against gram – negative/positive bacteria cultures. Two methods, the agar disk diffusion test and minimal inhibitory concentration.

The *Viburnum berries* aqua extract contain hydroxycinnamic acid, flavonoids and phenolic acid derivates that provide antimicrobial and antioxidant activity. Before and after, synthesis of AgNPs the total amount of hydroxycinnamic acid derivatives variation - from 4.64 to 1.02 mg CAE/g, similar variation of the total amount of flavonoids ~12 mg RE/g, respectively. Antioxidant activity were found between 27.51 and 31.21 µmol trolox equivalents per g fresh fruit based on FRAP. The AgNPs particle morphology is dependent on the type of plant. *Viburnum Zarnica- 2 /AgNPs* particles triangular in shape with sharp corners, 10 - 60 nm in size. *Viburnum Sargentii/AgNPs* particles spherical in shape, 10 - 50 nm in size. *Virburnum berries/AgNPs* strong inhibit the viability of gram-positive and gram-negative bacteria strains. The inhibition zone diameter increase by 0 to ~18 mm.

Keywords*:* plant extracts, Silver nanoparticles (AgNPs), *Zarnica- 2, Sargentii*

Fruit leaf extracts and their perspectives in the cosmetics industry - preliminary study

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Abstract

The leaves of many fruit crops can be a suitable raw material for making high-quality extracts with antioxidant and also anti-microbial properties. The aim of the study (project Nr.19-00-A01612-000006) was to determine the effect of harvesting time on the content of polyphenolic compounds and antiradical activity in autumn raspberry, sea buckthorn, Japanese quince and blackberry (cultivated and wild) leaves; to perform testing of selected extracts on pathogenic microorganisms in accordance with the requirements of cosmetic products.

The leaves of the plant were harvested four times a season from June to September, with an interval of one month. The following chemical analyses were performed: content of total polyphenols, flavonoids, tannins and antiradical activity (DPPH •). In accordance with the regulatory enactments regarding the compliance of the cosmetic products, for the selected samples of each plant the number of CFU of *Pseudomonas aeruginosa, Staphylococcus aureus, Candida albicans, Aspergillus brasiliensis* and the total count of aerobic microorganisms was determined.

Results. The time of harvesting has a significant effect on the content of biologically active compounds in the leaves. In July, the highest content of total polyphenols and tannins was found in Japanese quince leaves. Sea buckthorn, wild blackberry and autumn raspberry leaves harvested in August contained the highest total amount of polyphenols (431-743 mg $100g^{-1}$), while in blackberry leaves it was in September (415 mg $100g^{-1}$). Leaves collected in September contained the most tannins (0.6-2.1 mg $100g^{-1}$), except for Japanese quince. The antioxidant activity in leaf extracts differed significantly: in August it was highest for autumn raspberries, wild blackberries and Japanese quince, but in September – for sea buckthorn and blackberries.

Antimicrobial activity against *Staphylococcus aureus* was observed in all samples after seven days of storage and against *Pseudomonas aeruginosa* after fourteen days. During this time, activity against *Escherichia coli* was detected in four samples, except for wild blackberry leaf extract, which did exhibit these properties. None of the tested samples showed antimicrobial activity against *Aspergillus brasilliensis*. A tendency towards the properties of antimicrobial activity against *Candida albicans* in raspberry and Japanese quince samples was observed. In general, these two crops can be distinguished from other studied samples, as they exhibited antimicrobial activity against the largest spectrum of microorganisms. Sea buckthorn sample should also be noted, as the extract of these leaves inhibited the growth of all studied microorganisms.

As a result of the study, we can conclude that studies with combinations of different plant leaves which could provide higher antimicrobial activity are needed.

Keywords: leaves, antioxidant activity, antimicrobial properties, phenolic, flavonoids, tannins

Antioxidant and biological properties of *Querqua rubra* L. fruits

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Abstract

Forest seeds are increasingly used as food alternatives due to their nutritional composition and the fact that they are cost-effective, sustainable and eco-friendly. Acorn, the fruit of the oak has been used for centuries in animal (domestic and wild) feed but also as food in the human diet. The Food and Agriculture Organization of the United Nations (FAO) has defined acorns as non-wood forest products, namely "goods derived from forests that are tangible and physical objects of biological origin other than wood". In acorn species, while carbohydrates (41.52 to 78.83%) and fiber (13.11 to 51.76%) are the majority components, ash (1.78 to 3.21%), fat (0.76 to 3.08%) and protein (2.08 to 4.94%) are found in moderate amounts. Phenolic and volatile organic compounds, vitamins, sterols, aliphatic alcohols and fatty acids are bioactive compounds found in this fruits. Due to the tannins that imprint bitterness, an additional process of leaching, boiling or roasting is needed to make them edible. All these procedures must be performed in a controlled manner, with clearly established parameters to not affect the bioactive potential of oak fruits. It is consumed directly or processed into flour and used as a substitute for coffee, cocoa, muffins and traditional flat breads *pan 'ispeli*, *talo* and *ogi*. This study was aimed to investigate the red oak acorn fruits antioxidant and biological activity.

The acorns were collected at maturity when their color was yellow-brown or brown, being crossed by dark brown stripes and when the size of the oak fruits reached on average 2-4 cm in length and 1-1.5 cm in diameter. To evaluate the antioxidant and biological properties, total polyphenols content using the Folin-Ciocâlteu method, *in vitro* antibacterial potential of aqueous extracts against *Staphylococcus aureus*, *Bacillus cereus*, *Escherichia coli*, *Salmonella Enteritidis*, *Salmonella Typhimurium* and cell viability were determined.

Following the analyses performed, it was demonstrated that the raw red oak acorn is characterized by a high content of phenolic compounds (500.78±0.87 mg GAE/100g) responsible for numerous physiological, biological and biochemical functions due to their strong antioxidant activity. Red oak acorns are a promising base material with large amounts of secondary metabolites capable of providing protection against microbial contamination, especially having the ability to inhibit Gram-positive bacteria (*Bacillus cereus*; aqueous extract record a value of 14.5 mm for the inhibition zone diameter). Following anti-proliferative tests, it has been shown that raw aqueous extracts due to their antioxidant capacity and high polyphenol content, reduce the cell viability of HFL-1 and DLD-1 lines (76.50% and 45.29%) [1].

Keywords: acorn, antioxidant, forest seeds, inhibition, tannins, viability.

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Chemical constituents and antioxidant activity of *Aralia cordata* (*Aralia cordata* Thunb.) berry, seed, pulp, juice, and pomace

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Abstract

Over the last decades, the population has grown significantly; as a result, there is a growing need to seek ever new, innovative sources of biologically active components. Therefore, *Aralia cordata* berries can be a new source of innovative, biologically valuable functional foods and cosmetics products due to their phytochemical composition and antioxidant activity. In addition, *A. cordata* is a medicinal plant belonging to the *Araliaceae* family, grown mainly in China, Japan, and Korea, used in culinary and folk medicine.

This research aimed to determine the bioactive compounds of *A. cordata* berries, seed, pulp, juice, and pomace. Moreover, to investigate the essential oil composition of berries. The study was carried out at the LAMMC Institute of Horticulture Laboratory of Biochemistry and Technology. Antioxidant activity and total phenolic concentrations were examined in freeze-dried research objects ethanol/water mixture (70/30, v/v %). In addition, total anthocyanin, proanthocyanidins contents of the samples acidified ethanol/water mixture (70/29.5, v/v %) were determined. Essential oils of berries were extracted using the hydrodistillation method, and the chemical composition of essential oils were analysed by the gas chromatography-mass spectrophotometry. The total antioxidant activity was tested using the $DPPH^{\bullet}$ scavenging capacity, $ABTS^{\bullet+}$ radical cation assay, and ferric reducing antioxidant power (FRAP) and ranged from 11 to 419 µmol TE/g DW, 26 to 504 µmol TE/g DW, and 30 to 388 µmol TE/g DW, respectively. The yield of essential oils was 0.09 ml from 100 g of fresh berries. Eleven compounds from essential oil were identified in the berries; the highest amount was established of beta-pinene (61.49%), alpha-ocimene (30.10%), and limonene (5.41%). All other pharmacologically active compounds never exceeded 5% of the total amount in the sample.

The result demonstrated that *A. cordata* berry juice has significantly high antioxidant activity potential, and it is a good source of bioactive compounds. Therefore, it may be assumed that this plant's berry, juice, and by-products may be attractive for future functional food.

Characterization of avocado seed powder as an alternative and sustainable ingredient - citotoxicity evaluation and biological activity

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Abstract

The avocado seed is currently an underused waste product, resulting from the processing of pulp. Polyphenols, carotenoids and fibers were detected in the composition of this seed, imparting to it high biological and prophilactic activity. Moreover, some anti-fungicidal or anti- larvicidal effects were reported in previous research. Developing food products with avocado seed as an ingredient is highly desired for nutritional, environmental and economic reasons. The present study proposes the valorization of the conditioned avocado seed as ingredient in a hot drink, which is sensorial similar to the coffee surrogates.

The drink is obtained by infusionating the roasted avocado seed powder. The proximate composition and antioxidant capacity of the raw or conditioned avocado seeds and that of the novel drink were determined. The total polyphenolic content was assessed using Folin-Ciocâlteu method and assessed with Shimadzu UV-VIS 1700 (Shimadzu Corporation, Kyoto, Japan) spectrophotometer, set at 750 nm. The total carotenoids were extracted and assessed with Shimadzu UV-VIS 1700 spectrophotometer (Shimadzu Corporation, Kyoto, Japan), set at 450 nm. Starch determination was performed by the Ewers Polarimetric method with Bellingham + Stanley's ADP600 Series digital polarimeter (Kent, UK).

The highest content of polyphenols, 772,90 Mg GAE/100 g, was determined in the crude seed, while in the drink was as low as 17,55 Mg GAE/100. However, the proposed drink exhibited an antioxidant capacity of 90,27% RSA, while the crude seed 94,16 % RSA and the roasted seed 93,41 % RSA**.** This might be due to the high content of the total carotenoid compounds determined in the crude and roasted seeds (61,9056 mg/100g and 65,3448 mg/100g respectively). The proposed drink is safe to be consumed since it demonstrated high antiproliferative activity on Hs27 and DLD-1 cell lines, under 20% concentration. The average proliferation rate compared to the control untreated cells and the cell viability experiments demonstrated a dose-dependent response on both cell lines.

Keywords: avocado seed, sustainable ingredient, antioxidant capacity, cytotoxicity.

Antioxidant properties and aroma profile of swallow-wort (*Vincetoxicum lutea* L.) leaves extracts

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Abstract

Swallow-wort (*Vincetoxicum lutea* L.) grows in Europe, North America and Asia. It is an herbaceous perennial plant, which belongs to Apocynaceae family, Asclepiadoideae subfamily. Historically, swallow-wort leaves were used in the folk medicine for various medicinal purposes; the decoction from leaves was used to treat neurosis and malaria, while in Chinese medicine it was also used to treat internal fever, scrofula and scabies. Although it is a poisonous plant in large doses, according to Wang, et al. (2007) the swallow-wort possess some useful effects, e.g. diuretic, laxative and emetic. Glycosides, saponins and a small amount of volatile oils were reported in the leaves and other parts of the plant (Wang et al., 2008). However, the information on the composition of plant extracts is still scarce, particularly in case of using modern extraction methods. The aim of this work was to evaluate the advantages of supercritical fluid extraction with carbon dioxide (SFE-CO_2) and ultrasound-assisted extraction (UAE) for the recovery of phytochemicals from *V. lutea*.

The profile of aroma compounds in lipophilic *V. lutea* extract was studied by GC-TOF/MS. The chemical composition of *V. lutea* extract obtained by UAE was studied by UPLC-QTOF. Extract properties were evaluated by the *in vitro* assays, namely $DPPH^{\circ}$ scavenging and oxygen radical absorbance capacity (ORAC), while total phenol content was determined by *Folin-Ciocalteu* method. Antioxidant capacity of solid substances (dried leaves and residues after UAE) was evaluated using Quencher procedure for the above- mentioned spectrophotometric assays. The yield of lipophilic fraction recovered by SFE-CO_2 was 1.52%. More than 50 volatile compounds, consisting of saturated n-alkanes, acids, esters, amides, terpenes, aromatics, diterpenoids, triterpenoids, tocopherols and others, were identified in *V. luteum* extract. The major compounds were oleic acid, phytol, hexacosane, triacontane, α-tocopherol, octacosane, tetracosane, (Z)-9-octadecanamide, heneicosanol, squalene, 2-pyrrolidinone and ethyl hexadecanoate. The UPLC chromatograms of extract obtained by UAE revealed the presence of several phenolic compounds: chlorogenic acid, caffeic acid, isoquercitrin, kaempherol and various quercetin glycosides, such as quercetin 3-arabinoside, quercetin 7-xyloside. The antioxidant capacity of *V. lutea* leaves and residues after extraction measured by different methods decreased with increasing polarity of solvent used for extraction.

It may be concluded that properly designed extraction process for *V. lutea* leaves enables recovering of valuable bioactive compounds with high antioxidant capacity.

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Plant Biology Infrastructure (TAIM) – a platform for plant phenotyping, plant-based innovation and science-intensive developments

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Abstract
The aim of TAIM is to ensure transfer of knowledge and innovation from Estonian R&D institutions to agri-food sector. TAIM combines the competence and infrastructure of Estonian R&D institutions into a common service platform, offering innovative molecular biology services, precision breeding and classical measurements of plant traits related to yield and its quality. TAIM is a tool to implement the objectives of EU Green Deal, providing high-quality and innovative input for agriculture, supporting sustainable use of resources and transferring innovation from research to producers.

TAIM serves to:
1) apply more resource-efficient, environmentally and climate friendly agrotechnology,
2) accelerate plant breeding,
3) add value to plant-based materials,
4) create innovative plant products,
5) accelerate innovation and green deal by involving the strengths of Estonian ICT sector.

We offer real-time monitoring of plants both on the field and in the lab. Several installations are already operating and several investments are under way in order to increase our capabilities and to enable offering services required by the agri-food sector. The aim is to create contemporary infrastructure for growing and phenotyping plants in different environmental conditions in Estonia. A novel drought and excessive watering field test site is being developed in Jõgeva, Estonia, where the performance of plants is measured with drones equipped with different cameras and with different remote sensors. A platform for deep sequencing and microscopy studies of plant pathogens has been established in TalTech. Portative measurement equipment for analysing photosynthesis and water use of plants is being developed at the University of Tartu. A 3D spectroscopy-based fruit sorter will be installed in Polli at the Estonian University of Life Sciences to enable efficient fruit phenotyping.

TAIM is open for local and international cooperation, both with the academia and private sector. Our thus far collaborators are breeding institutions and agrochemical companies such as Nordic Seeds, Bayer Crop Science, BASF etc. Feel free to contact us! Let's pursue further innovation in agri-food sector! www.taimebioloogia.ee

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Closing remarks of the conference

Dear all,

We had 89 registered participants from ten different countries around the world – Estonia, Latvia, Lithuania, Poland, Finland, Serbia, Norway, Romania, United Kingdom and India. The conference reflected the relevant topics related to plant genetic resources, fruit and berry breeding, cultivation and processing technologies, pests and diseases, yield quality, by-product treatment and valorization up to the product development.

In the light of green deal and sustainability we need to adapt with the changing world conditions. Fruit breeding is a long-term process – so the breeders should be able to predict and aim the needs of future generations 10-25 years ahead, which is a tricky task. It means that we always need to look into the future, adapt and solve the future problems already today.

As several times mentioned during the conference, Estonian apples are appreciated in Latvia, and we can say the same to numerous cultivars grown in Estonia, but originating from Latvia, Poland and many other countries. This has provided us a common interest of research, valuable network of colleagues, and we have become friends as well. In relation to cooperation and collaboration of different countries, the today's event and these valuable contacts will help us to strengthen our connections even more.

There are common interests, similar problems and joint aims to be conquered – e.g. spreading of pests and diseases; consumer interaction; production of healthy food etc. The new technologies are coming in like robotics and precision farming techniques to ease our work and optimize the working processes, diminish the production loss in order to save the time and finances and to be more effective and sustainable. The cooperation and collaboration between the producers, researchers, stakeholders and policy makers is more and more important with each day.

In conclusion, the conference was for sure very successful, interesting and useful to all the participants based on the positive and kind feedback that came from your side. Our invited speakers and poster presentations did get high ratings during the event via the Worksup conference platform. We did learn today and we certainly have a lot to learn from each other in the future as well.

The oregnizers of the Polli 100 conference would like to thank all the participants, dear colleagues and young researchers for the great presentations and for sharing the valuable results of your research. Special thanks to the organizing team – to Vallo Vahenurm, Hedi Kaldmäe and Karmen Pääso. We are thankful to all of our supporting colleagues and friends. We acknowledge European Regional Development Fund for financing the organizing of the conference.

Thank you all for making the conference a memorable event!

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